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Computed Tomography Findings in Chronic Rhinosinusitis Patients with and without Allergy

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SUMMARY The purpose of this study was to compare the paranasal sinus mucosal thickenings, bony changes consistent with chronic sinusitis, and bony anatomic variations detected by computed tomography (CT) in chronic rhinosinusitis patients with and without allergy. Three hundred and thirty-nine patients with chronic rhinosinusitis were analyzed for their allergic status by performing skin prick test. Two hundred and thirteen patients (62.8%) had at least one positive skin prick test (allergic patients, male/female: 85/128, mean age: 29.1 $\pm$ 1.2). One hundred and twenty-six patients (37.2%) were included in the non-allergic group (male/female: 53/73, mean age: 31 $\pm$ 2.2). Maxillary mucosal thickening and frontal hypoplasy were significantly more common in allergic chronic rhinosinusitis patients. Moreover, pneumatized uncinate process is apparently more common in the allergic group than non-allergic group, and statistical analysis revealed marginal significance (p = 0.0535). In conclusion CT findings of allergic chronic rhinosinusitis patients are comparable to the CT findings of chronic rhinosinusitis patients without allergy. However, presence of maxillary mucosal thickening, frontal hypoplasia or pneumatized uncinate process in the CT scan of a patient with chronic rhinosinusitis could be of clinical significance, and might guide the otolaryngologist for the evaluation of the presence of allergy.

Chronic rhinosinusitis is one of the most common reasons for patients to consult the ENT specialist. The management of this condition is problematic and should include consideration of contributory and potentially correctable medical and anatomic factors. Allergy is an important consideration in the evaluation of patients with rhinosinusitis. A relationship between allergy and rhinosinusitis has been described for many years. Prevalence of sinusitis is increased in allergic individuals.[1-4] A significant proportion of patients who diagnosed as having chronic rhinosinusitis have at least one component of allergy.[5-7] Previous studies using CT scoring systems suggested that allergic patients had more advanced sinusitis when compared to non-allergic patients in relatively smaller groups of subjects.[8,9] However, a detailed analysis of paranasal sinus abnormalities detected by computed tomography (CT) in chronic rhinosinusitis patients with or

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without allergy has not yet been performed. The purpose of this study was to compare the paranasal sinus mucosal thickenings, bony changes consistent with chronic sinusitis, and bony anatomic variations detected by CT in chronic rhinosinusitis patients with and without allergy.

MATERIALS AND METHODS

This study included 339 consecutive patients who were diagnosed as having chronic rhinosinusitis in our clinic. The diagnosis of chronic rhinosinusitis was defined as the presence of rhinorrhea, cough, and nasal congestion that had persisted for at least 3 months despite well-proven medical treatment. Patients with previous alterations of the paranasal sinus anatomy due to trauma, malignancy, or surgical interventions, and patients with documented allergic disorders were eliminated from the study. Informed consent was obtained from all participants.

Patients were analyzed for their atopic status according to the result of a skin prick test with the most common allergens including grass mix, fat hen (*Chenopodium album*), dandelion (*Taraxacum vulgare*), maize (*Zea mays*), tree pollens, lime (*Tilia platyphyllos*), chestnut (*Castanea vulgaris*), plane (*Platanus vulgaris*), elm (*Ulmus campestris*), olive (*Olea europea*), sorrel (*Rumex acetosa*), and house dust mites (*Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*). The skin-prick test was performed on the volar side of the forearm, and reactions with an induration of more than 5 mm in diameter were regarded as positive. Histamine hydrochloride 10 mg/ml and allergen diluents were used as positive and negative controls, respectively.

The patients were divided into two groups according to the results of the skin-prick test. Two hundred and thirteen patients (62.8%) who had a typical history for atopy plus at least one positive skin-prick test were regarded as allergic patients (male/female: 85/128, mean age: 29.1 ± 1.2 years). The remaining 126 patients (37.2%) were included in the non-allergic group (male/female: 53/73, mean age: 31 ± 2.2 years). CT imaging was performed by using Siemens 792CT100028 or Siemens 792CT11730 CT scanner. Contrast was not administered. The images were collimated to 5 mm and obtained at 3-mm increments from the glabella to the dorsum sella. The CT scans of each patient were evaluated by experienced radiologists. CT scans of each patient were evaluated for the presence of various bony changes consistent with chronic sinusitis and bony anatomic variations of the paranasal sinuses including concha bullosa, paradoxical middle concha, inferior concha hypertrophy, tail of inferior concha hypertrophy, Agger nasi cell, frontal recess, Haller's cells, pneumatized uncinate process, pneumatized crista galli, osteomeatal complex (OMC) closed septum deviation, OMC disease, maxillary hypoplasia, frontal hypoplasia, and sphenoid hypoplasia. Any evidence of mucosal thickening of the paranasal sinuses detected on CT was considered "abnormal",[10] and was noted.

The Statistical Package for Social Sciences (SPSS) for Windows and Graphpad Instat softwares were used to analyze the data. The age distributions between allergic and non-allergic patients were compared by using Student's t test. The distribution of the above-mentioned bony anatomic variations and mucosal abnormalities between patients with or without allergy was compared using chi-square (χ^2) test and Fisher's exact χ^2 test. A p value below 0.05 was considered as statistically significant.

RESULTS

The age and sex distributions of the two groups were comparable. Maxillary sinus mucosal thickening, anterior ethmoid mucosal thickening, posterior ethmoid mucosal thickening, frontal sinus mucosal thickening, and sphenoid sinus mucosal thickening were present in 116 (54.5%), 68 (31.9%), 46 (21.6%), 65 (30.5%), and 50 (23.5%) patients, respectively, in the allergic group; and in 47 (37.3%), 28 (22.2%), 32 (25.4%), 45 (35.7%), and 25 (19.8%) patients, respectively, in the non-allergic group (Table 1). Maxillary sinus mucosal thickening was significantly more common in the allergic group ($p < 0.05$). Among bony findings, concha bullosa, paradoxical middle concha, inferior concha hypertrophy, tail of inferior concha hypertrophy, Agger nasi cell, frontal recess, Haller's cells, pneumatized uncinate process, pneumatized crista galli, OMC closed septum deviation, OMC disease, maxillary hypoplasia, frontal hypoplasia, and sphenoid hypoplasia were detected in 71 (33.3%), 19 (8.9%), 100 (47%), 4 (1.9%), 84 (39.4%), 62 (29.1%), 33

(15.5%), 17 (8.0 %), 55 (25.8%), 11 (5.2%), 95 (44.6%), 9 (4.2%), 29 (13.6%), and 1 (0.5%) patients, respectively, in the allergic group; and 53 (42.1%), 14 (11.1%), 54 (42.9%), 7 (5.6%), 55 (43.7%), 37 (29.4%), 18 (14.3%), 3 (2.4%), 35 (27.8%), 3 (2.4%), 57 (26.8%), 2 (1.6%), 8 (6.3%), and 0 (0%) patients, respectively, in the non-allergic group (Table 2). Frontal hypoplasia was significantly more common in the allergic group ($p < 0.05$), and there was marginal significance regarding the frequencies of pneumatized uncinate process between allergic and non-allergic patient groups ($p = 0.0535$).

DISCUSSION

Allergy has long been proposed to contribute to the development of sinusitis. In allergic patients, antigen-antibody reactions and release of various inflammatory mediators including histamine increase vascular permeability and destabilize lysosomal membranes leading to inflammation, mucosal swelling, and inhibiton of mucociliary clearance. These inflammatory reactions may lead to obstruction of sinus ostia, sinus stasis and may contribute to the formation of rhinosinusitis.[5,11] Nasal allergen challenges can result in symptoms and radiographic findings of sinusitis.[3] Accordingly, prevalence of sinusitis is increased in allergic individuals.[1-4] Significant increase in positive skin tests was shown among 224 army recruits with acute sinusitis versus a homogenous control group.[7] More than half of the children with chronic sinusitis had positive skin test.[6] Recently, up to 84% of 190 patients with chronic

Table 1 Mucosal abnormalities of the paranasal sinuses in allergic chronic rhinosinusitis patients and in non-allergic chronic rhinosinusitis patients

Mucosal abnormality	**Allergic group** (n = 213)	**Non-allergic group** (n = 126)	*p*
Maxillary sinus mucosal thickening	116 (54.5%)	47 (37.3%)	< 0.05
Anterior ethmoid mucosal thickening	68 (31.9%)	28 (22.2%)	> 0.05
Posterior ethmoid mucosal thickening	46 (21.6%)	32 (25.4%)	> 0.05
Frontal sinus mucosal thickening	65 (30.5%)	45 (35.7%)	> 0.05
Sphenoid sinus mucosal thickening	50 (23.5%)	25 (19.8%)	> 0.05

Table 2 Bony computed tomography (CT) findings of the paranasal sinuses in allergic chronic rhinosinusitis patients and in non-allergic chronic rhinosinusitis patients

CT finding	**Allergic group** (n = 213)	**Non-allergic group** (n = 126)	*p*
Concha bullosa	71 (33.3%)	53 (42.1%)	> 0.05
Paradoxical middle concha	19 (8.9%)	14 (11.1%)	> 0.05
Inferior concha hypertrophy	100 (47%)	54 (42.9%)	> 0.05
Tail of inferior concha hypertrophy	4 (1.9%)	7 (5.6%)	> 0.05
Agger nasi cell	84 (39.4%)	55 (43.7%)	> 0.05
Frontal recess	62 (29.1%)	37 (29.4%)	> 0.05
Haller's cells	33 (15.5%)	18 (14.3%)	> 0.05
Pneumatized uncinate process	**17 (8.0 %)**	**3 (2.4%)**	**= 0.0535**
Pneumatized crista galli	55 (25.8%)	35 (27.8%)	> 0.05
OMC closed septum deviation	11 (5.2%)	3 (2.4%)	> 0.05
OMC disease	95 (44.6%)	57 (26.8%)	> 0.05
Maxillary hypoplasia	9 (4.2%)	2 (1.6%)	> 0.05
Frontal hypoplasia	**29 (13.6%)**	**8 (6.3%)**	**< 0.05**
Sphenoid hypoplasia	1 (0.5%)	0 (0%)	> 0.05

rhinosinusitis had positive allergy testing for common perennial and seasonal inhalant allergens.[5] In our study, we demonstrated that 62.8% of patients with chronic rhinosinusitis had positive skin prick test for allergy. Hence, our results confirmed those previous observations in a larger cohort.

Coronal CT scans have dramatically improved the imaging of the nasal cavity and paranasal sinuses. Subtle variations or anomalies of paranasal bony anatomic structures and mucosal abnormalities can easily be detected with coronal plane CT imaging.[10,12] To our knowledge, an association between CT findings of the paranasal sinuses and allergic status has not been extensively investigated yet. In this study, we hypothesized that allergic inflammation in the mucosa of the paranasal sinuses might have caused remodeling process of the upper airways, causing anatomical and mucosal variations in CT findings of allergic rhinosinusitis patients. Hence, we divided a large cohort of chronic rhinosinusitis patients according to their allergic status by using skin prick test, and compared the paranasal sinus mucosal thickenings, bony changes consistent with chronic sinusitis, and bony anatomic variations in allergic and non-allergic groups. We demonstrated that prevalences of the majority of the above-mentioned CT findings were comparable in those two subgroups of chronic rhinosinusitis patients. However, maxillary mucosal thickening and frontal hypoplasy were significantly more common in allergic chronic rhinosinusitis patients ($p < 0.05$). Moreover, pneumatized uncinate process is apparently more common in the allergic group than non-allergic group, and statistical analysis revealed marginal significance ($p = 0.0535$).

Thickened mucosa in the sinonasal cavity is a significant site of functional, immunologically active tissue. Constant exposure to inhalant allergic challenges in the sinus mucosa can trigger and perpetuate inflammatory reactions, appearing as mucosal thickening on CT scans. Allergic subjects are likely to have significant and extensive sinus disease, reflected in CT scans as mucosal thickening.[8] Chronic inflammation and resulting mucosal hypertrophy might be more common in the maxillary sinus as a consequence of poor drainage of the antra due to the position of the ostia.[13] However, data regarding the prevalence of maxillary mucosal thickening in allergic patients are conflicting. Mucosal thickening of the maxillary sinuses was more commonly observed in non-allergic persons than in allergic patients in a previous study using conventional sinus radiographs.[14] Since conventional sinus radiographs are much less sensitive than CT scans for detecting sinus mucosal abnormalities, and an error rate of up to 75% was reported when the accuracy of conventional radiographs was compared with that of sinus CT for diagnosing sinusitis,[15,16] the results of this latter study remains questionable. In our group, maxillary mucosal thickening is more common in allergic chronic rhinosinusitis patients than non-allergic patients. Therefore, presence of maxillary mucosal thickening in patients with chronic rhinosinusitis might increase the likelihood of an allergic background. On the other hand, mucosal abnormalities have been detected in more than 40% of adult subjects without evidence of active sinusitis. Moreover, no relationship was evident between a history of allergy and mucosal abnormality in ethmoid, maxillary and frontal sinuses.[13] Furthermore, pathogenesis of the observed mucosal thickening may be related to other inflammatory conditions, including rhinovirus infections.[17] Therefore, much effort is still needed to establish the association between sinusal mucosal abnormalities and allergic status in patients with chronic rhinosinusitis.

The frontal sinus is the last paranasal sinus to develop. The earliest pneumatization of the frontal sinus begins around the age of two years, and the pneumatization process continues until the final size is achieved after puberty. Chronic sinus inflammation may interfere with the normal sinus development. Patients with cystic fibrosis and chronic sinusitis had less pneumatized frontal sinuses than normal subjects.[18] Allergic inflammation might cause further impairement of the pneumatization of the frontal sinuses, causing inreased prevalence of frontal sinus aplasia in the allergic group.

Pneumatization of the uncinate process is an anatomic variation that occurs infrequently, being present in only 2.5% of 202 patients with chronic sinus-like complaints. Likewise, this anatomic variation was present in only three patients in the non-allergic chronic rhinosinusitis group in our study (2.4%), while it was more commonly observed in the

allergic chronic rhinosinusitis group (in 17 patients, 8%). Presence of the pneumatized uncinate process can impair the sinus ventilation.[19] Nasal edema or secretions caused by allergic inflammation might further impede sinus drainage, causing increased risk for the development of chronic rhinosinusitis in allergic patients. However, since the number of subjects having pneumatized uncinate process is quite limited in both allergic and non-allergic groups, and because the difference regarding the prevalence of this anatomic variation reveals only marginal significance, larger studies would be needed to confirm this speculation.

In conclusion, the majority of chronic rhinosinusitis patients have positive skin test for allergy. CT findings of those patients are largely comparable to the CT findings of chronic rhinosinusitis patients without allergy. However, maxillary mucosal thickening, frontal hypoplasy and pneumatized uncinate process are more common in allergic rhinosinusitis patients. Therefore, although CT is not more advantageous than skin prick test for evaluating the status of allergy, the presence of those above-mentioned CT findings increases the likelihood of an allergic status in a patient with chronic sinusitis, and might guide the otolaryngologist for the evaluation of the presence of allergy.

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